

Code of practice for

Safety in erecting structural frames

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- Incorporated Association of Architects and Surveyors
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- Institution of Occupational Safety and Health
- Institution of Structural Engineers
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Foreword

This revision of BS 5531 has been prepared under the direction of the Civil Engineering and Building Structures Standards Committee, and supersedes BS 5531:1978, which is withdrawn.

This code was originally written in 1978 against a background of concern about the number of accidents and collapses occurring during the erection of structural frames. A recurring feature in those accidents was poor practice. It was therefore considered that presenting good practices in code form would beneficially affect the future accident situation and would result in increased efficiency in the construction industry. It was considered that there were certain features of good erection practice which were common to all types of frames. This information is contained in section 3 of the code. A study of that section is a prerequisite to a proper application of the rest of the code.

Examples shown in the text are representative of acceptable practice but organizations may use their own tried techniques.

In this revision the text has been extensively altered in detail to conform with present legislation and guidance.

In addition to legislation relevant to the subject of this code and listed in section 1, clause 3, attention is also drawn to the Health and Safety Executive Guidance Notes GS 28/1-4, "Safe erection of structures".

Attention is also drawn to BS 6100 "Glossary of building and civil engineering terms".

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Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 36, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This code of practice makes recommendations concerning safety in erecting the principal types of structural frames, mainly in precast concrete and steel. Consideration is also given to the following:

- a) space frameworks
- b) timber frameworks
- c) aluminium frameworks
- d) plastics frameworks

This code does not include recommendations on work involved in the erection of in situ concrete frames (see BS 5975).

This code does not deal with those aspects of site safety which are generally applicable to all construction operations and for which guidance and information are readily available elsewhere (e.g. use of hand tools, ladders, etc.).

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Definitions

For the purposes of this code the following definition applies.

method statement

a document setting out a safe system of work, in detail dependent on the complexity of the work involved

NOTE Other terms used in this code are those in common use during construction operations.

3 Legislation (general)

The following list gives the principal legislation, current at the date of publication of this code, affecting safety in erection work or relating to operations associated with it.

Health and Safety at Work etc. Act, 1974

Factories Act, 1961

Statutory Instrument 1961 no. 1580

Construction (General provisions) Regulations, 1961

Statutory Instrument 1961, no. 1581

Construction (Lifting Operations) Regulations, 1961

Statutory Instrument 1966, no. 94 Construction (Working Places) Regulations, 1966

NOTE When applying this code, users are advised to ascertain the current state of legislation.

Section 2. Primary safety considerations

4 Competence

In this code it is assumed that all those engaged in all aspects of the work are competent for the task. Care should be taken to ensure that persons are only called upon to carry out tasks which may reasonably be expected from persons of their levels of competence.

The term competent person is not a defined term and has been the subject of legal discussion. However, as a guide, a person may be regarded as able to perform the duty if he has sufficient practical and theoretical knowledge and actual experience of the work in question to enable him to recognize hazards associated with the work being undertaken.

5 Training

Contractors should be able to show that training in safe working practice has been given to site supervisory staff and other employees and that they are competent in their designated jobs.

Training needs should be identified as early as possible and this can sometimes be assisted by an examination of incidents and accident records.

The training of foreman, supervisor and site manager levels will need to extend to an understanding of the implications of method statements, the significance of legal requirements, project planning, the establishment and running of the site organization and the provision of project induction training to operatives.

6 Responsibility

This code can best be applied as part of a comprehensive approach to safety from planning to execution when clearly defined areas of responsibility have been laid down and communicated to all those engaged in the work.

Responsibilities for planning safe erection can, and should, start at the initial design stage. Designers should take into account the need for, and the practicability of, safe methods of working during erection.

The structural analysis and design should identify those features of the structure which have a critical influence on its overall and continuing stability and structural integrity during construction. The fabricating and/or erecting contractor would retain the responsibility for choosing or accepting a particular method of fabrication and erection.

7 Supervision

Supervision should be considered as an overriding requirement.

Supervisors should be given instructions on the work they are to oversee. Supervisors should pay particular attention to whether the relevant drawings, documents and methods of erection procedure have been issued and whether, in their experience, they are adequate to allow a safe method of working to be established.

Supervisors should be competent to recognize and deal with a potentially dangerous situation.

8 Design

The general term design/designer refers to all stages from concept through to structural design and detailing. This may include design for both permanent and temporary works and involve one or more designers.

Section 3. Considerations affecting all erection tasks

9 Erection methods, design stage

9.1 General

Guidance on the design, erection and use of the materials used for structural frames can be obtained from the following:

- CP 118 Aluminium
- BS 5268 Timber
- BS 5950 Steel
- BS 8110 Concrete
- BS 5975 Falsework

9.2 Lifting and handling of framework elements

The component parts or pre-assembled portions of a structure should be designed in such a way that they can be handled, transported, lifted and positioned safely. Attachment points for slings and eyebolts should be marked when lifting at other positions could cause harm to the structure (e.g. distortion or weakening) or instability.

9.3 Interconnection of members and elements

Members and elements should be so designed that they cannot be interconnected incorrectly during assembly or erection.

9.4 Lack of stability and weakness

The designer should consider the risks due to lack of stability and weakness which may occur during erection and take appropriate action.

9.5 Erection

The structure on which erection work is being performed will have been designed for the acceptance of normal design loading. In course of erection temporary loads may be applied due to deposited material, loads incidental to the erection procedure or the effect of wind on partially completed frameworks. It is essential that the erection procedure takes due account of these loadings at the design stage.

10 Planning for erection

10.1 General

It is important that there should be a coordinated plan for all matters affecting erection. In particular, account should be taken of any limitations that may exist at the site in means of access, storage and the size or weight of components. Careful consideration should be given to planning the sequence of erection. As much of the structure as is practicable should be pre-assembled at ground level.

10.2 Temporary attachment

Special attention should be given to the need for temporary attachments and lifting connections (e.g. working platforms, etc.). Such attachments require the same design considerations as those for permanent use. Whenever possible these attachments should be fitted at the fabrication stage.

11 Drawings and instructions

11.1 Drawings

Copies of all relevant working drawings and instructions should be kept on site so that they are easily available and accessible to all concerned. The use of transparent waterproof covers for the protection of drawings on site should be considered. An additional complete master set should be kept in the site office for reference purposes only.

The erection scheme drawings should show specifically how stability, and in particular, lateral stability, is to be achieved at each successive step in erection.

11.2 Instructions

11.2.1 General. The communication of safe erection procedures is vitally important, particularly to those who actually fix the components in place. It is recommended that the details of these procedures should be clearly shown on drawings or fully described in written instructions or instruction manuals. Any unusual or key features should be clearly emphasized, for example.

- a) Both these diagonal bracing members have to be present and fully secured in position before any erection work on an adjacent frame or upper frame is commenced

or

- b) The stability of the roof steelwork depends on the presence of the brickwork at the gable ends. The steelwork should not be erected until 7 days after the brickwork has been completed or until such a time as it has developed sufficient strength, and a strong and rigid connection to it can be made.

11.2.2 The erection scheme. The instructions should include information about all measures that need to be adopted and provisions made to allow the work to take place to a predetermined programme. The following items, not so far mentioned, might form part of a typical scheme.

- a) The sequence and methods to be adopted for the supply and storage of components and materials.
- b) Equipment and tools to be used and their capacity.

c) The type and positioning of lifting equipment, including methods of dealing with the handling, lifting and fixing of large or heavy components. Such methods should ensure the components are not over-stressed during lifting.

d) The use of temporary bracings, props, guys or other measures to ensure stability at each (successive) stage.

e) The provision of access and working platforms.

f) Methods for dealing with particularly hazardous operations (e.g. work in close proximity to the general public; work over roads, railways and water; the use of radiography; proximity of overhead power lines, etc.).

11.2.3 Deviation from the erection scheme. Should circumstances arise on site that require a deviation from the erection scheme (see **11.2.2**), the supervisor has to satisfy himself that such a deviation will have no detrimental effect upon the stability or safety of the structure being erected.

In any case of doubt he should seek advice about and obtain approval for such changes. If these changes affect the integrity of the structure, reference should also be made to the designer before any changes are made.

12 Coordination of operations

12.1 General

Erection should be arranged in such a way that work in one place does not create an additional hazard either in the same place or in another.

12.2 Work occurring simultaneously at different levels

Where erection work is taking place immediately above areas where other work is in progress, measures should be taken to protect those working below.

12.3 Work occurring simultaneously at or near the same place

Hazards may arise (e.g. with subcontractors) where men undertaking different tasks are working close to each other. Special care is necessary in supervision to ensure that those engaged on one task do not introduce a hazard by interfering with or modifying the work of those engaged on another. Serious consequences can arise where a component is moved out of its intended position to make room for another without information or permission being given.

13 Site preparation

13.1 General

The contractor should check the site for hazards before starting work, and should note any special features. There should be suitable unobstructed safe access for delivery vehicles, cranes and other plant. The position of overhead services, particularly live electric cables, should be checked, as should the positions of any buried services which may be vulnerable to damage by traffic. Movement about the site should be planned with the provision of sound access ways. This may require the formation of temporary roads and hard standings designed for the loads involved. Separate clean and clear pedestrian access ways may be necessary.

The increasing use of access equipment requires the provision of a higher standard of site preparation. The control of other site activities, such as trench excavation, may be necessary so that the use of access equipment is not hindered.

13.2 Storage area

Sufficient area should be allocated for the stacking, storage and handling of materials and components. This area should be clean, even, firm and reasonably level and of adequate size, clear of any of the hazards mentioned in **13.1**.

Stacking should be such that no overloading either of the storage area or of the individual units occurs. Bearers will need to be used between units and the height of the stack should be limited as far as possible. The need to climb on to the stack should be avoided.

If frames are used for storage, it is essential that they are stable and that they are loaded and unloaded so as to minimize eccentric loading.

13.3 Above ground storage

Components may need to be stored on the framework. Positions, layout and loading have to be determined before the commencement of work and loads should be placed without impact.

14 Setting-out, levelling and alignment

14.1 Precautions in setting-out

The required degrees of accuracy should be clearly determined before setting-out is begun. The limiting tolerances should be stipulated if they have not already been included in the specification. Failure to achieve these tolerances may result in dangerous improvisations.

14.2 Levelling and alignment

Levelling and alignment is a potentially dangerous stage in the erection sequence, when temporary instability may occur.

Before levelling and alignment is performed on a framework fastenings should not be slackened or withdrawn until the stability of the framework in this condition has been checked by a competent person and it has been declared safe to proceed. As far as possible all permanent bracing members should be in position before any attempt is made to adjust level or alignment. Where continued stability may be in doubt temporary bracing members or guy lines should be introduced and made secure in such a way that their effectiveness is not impaired by adjustments to the framework.

In a multi-bay framework, a preferred method is to complete levelling and alignment to within two bays of the erection front, in the case of heavy steelwork, and to within four bays, in the case of light steelwork. It is not recommended that the whole framework of the building is erected before levelling and alignment.

15 Bearings allowing movement

Although the main use of rotational sliding bearings is on bridges, they may be used on other types of structures. They usually have a relatively slender key to prevent movement and under erection conditions this may be insufficient to ensure stability. Temporary supporting frames may therefore be necessary until sufficient beams have been erected and tied together.

16 Connections

16.1 General

All connections should have sufficient space around each fastener to allow use of the spanner, socket or, at weld positions, to allow access of the electrode etc. They should be arranged to minimize the time working at height by both operatives and supervision staff.

See also clauses 25 and 27.

16.2 Column splices

Where joints occur in the length of the columns they should be located to take advantage of the access and working platforms that can be provided by incoming floor beams. Sufficient fixings should be provided to ensure the stability of the upper section of the column until it is adequately tied in to the rest of the structural framework.

16.3 Beam splices

Where joints are made in beams to achieve continuity over their length, unless specific provision has been made in the design, each part of the beam should be temporarily supported until the connection has been completed. Working platforms from which the connection is made may also be incorporated.

17 Holding down arrangements

17.1 Design aspects

Anchorage should be designed to ensure that they have adequate strength and can be installed in the manner intended and function properly. Construction difficulties should be anticipated so that holding down bolts are secured or fastened in the desired position during placing of foundation concrete. Provision should also be made for alignment and levelling.

The designer should specify what time interval should elapse or what strength should be achieved before fixing is made to an anchorage and load applied.

Where holding down is dependent on the presence of counterweights, the erection sequence should be carefully designed so that equilibrium can be maintained at all stages.

The use of a length of a flat, angle or channel which accepts two or more bolts is recommended to anchor the bolts. This distributes the load over a greater area of concrete and aids accurate positioning of the bolts.

Attention is drawn to the following common causes of anchorage failure which indicate the need for care in design and during construction.

- a) Plate washers of insufficient thickness or diameter under the heads of holding down bolts. (The washer should be large enough and strong enough to bridge the adjustment sleeve when one is used. A thickness of at least one half the holding down bolt diameter is likely to be required.) Washers under the nuts of holding down bolts should also be of adequate dimensions.
- b) Insufficient curing of epoxide resin materials.
- c) Holding down bolts or fittings difficult to fix or located in positions where they coincide with reinforcement or other items. This may lead to displacement of bolts or reinforcement.
- d) Insufficient length of holding down bolts, insufficient projection or wrong position leading to their omission or weakened fastenings.

17.2 Erection precautions

17.2.1 It is often the case that the design requirements for the holding down arrangements in the finished structure are nominal and that their value is largely related to positioning. However, it is possible that far larger stresses may be applied during erection. The erection scheme should demonstrate that all stresses likely to be introduced in the holding down arrangements during erection are acceptable.

17.2.2 The strength of concrete, brickwork, grout, etc. on which an anchorage depends for its effectiveness should be allowed to develop to a sufficient extent before any fastening is made or load applied.

17.2.3 It is desirable that pockets or adjustment space surrounding holding down bolts should be kept dry in winter and not allowed to become full of water which may subsequently freeze. (The expansion effect on freezing may fracture the concrete and weaken the anchorage.)

17.2.4 The effect of wind should be taken into account in all stages of erection. It is necessary to ensure that the anchorage and fastenings are adequate to accept wind load and that components, materials and all parts of the permanent construction liable to be subject to uplift or disturbance are properly held down.

17.2.5 Where the erection procedure adopted is likely to bring about uplift in any portion of the framework, the holding down arrangements in that portion should be complete, effective and adequate before the work starts. The adequacy of the holding down arrangement should be checked by calculation and its presence verified by inspection.

18 Use of cranes and other lifting devices

18.1 General

Efficient use of lifting equipment depends on sequential and correct stacking of material and adequate access thereto. Areas of hardstanding should be firm, level and suitably maintained to permit their use.

The principal characteristics of various forms of crane, the more common hazards and potential dangers in use and the precautions to be taken are described in CP 3010.

The recommendations contained in that code should be followed. In addition the following recommendations pertinent to the erection of structural frames should be observed.

18.2 Use of cranes in artificial light

If cranes are to be used for the erection of frames in artificial light, reference should be made to **29.4**.

18.3 Multiple lifts

Tandem lifting is dealt with in **1.11.5** of CP 3010:1972. Multiple lifting, although not recommended in CP 3010, may exceptionally be necessary where it has been impossible to eliminate it from the planning, assembly and erection scheme. Such lifting is only permissible provided that it is carefully planned by competent design staff and subject to a high degree of supervision and control. One person should be nominated to be in charge of the operation, and crane drivers should obey his instructions only.

Among the points to be considered are the following.

- a) Where a load is to be moved by two or more mobile or crawler track cranes, the path required to be followed by each crane should be very clearly marked. It is of the greatest importance that there should be coordinated movement and no deviation from the planned route. All persons involved in movements of this kind should be given special instruction and before it commences should be fully conversant with the task and the nature and extent of their own duties.
- b) Each crane's share of the load can only be approximated and in making an assessment of this load a considerable safety factor should be allowed. In deciding the crane capacity, allowance should be made for possible oscillation of the load, dynamic effects and variations in ground level which may cause one crane to be relieved of the load and additional burden placed on the others.

18.4 Work in the vicinity of suspended loads

Loads which are suspended close to a framework and particularly when near working positions should be manoeuvred with considerable care.

Loads in course of movement should always be under complete control and it is preferable for the load to be moved too slowly rather than too quickly. Rotation and swinging of the load in course of lifting should be anticipated and clearances should always be adequate to prevent the load from fouling the structure and erection equipment. Guide ropes should be used when necessary to keep the load under complete control.

The support provided by a crane should never be removed until the component being fixed is adequately secured.

18.5 Jammed parts

18.5.1 When parts which are being placed in position with the use of a crane or lifting gear become jammed, and require to be freed, it is essential that a safe procedure be adopted.

18.5.2 Danger may arise in several ways such as:

- a) overloading of the crane or hoisting equipment, e.g. through attempts to pull a vertically suspended load sideways or failure of the slings or lifting attachments;
- b) overloading of parts of the structure or the whole of the structure;
- c) sudden release, causing risk of injury to men who may be struck or caused to fall by the swinging load;
- d) damage to the jammed part which may lead to an accident or further misfit of parts.

18.5.3 A safe procedure for freeing jammed parts should be decided by inspection and dimension checks to ascertain:

- a) whether the jammed part is the correct part;
- b) whether the jammed part is of the correct size;
- c) whether the framework dimensions are correct for the acceptance of the part.

18.5.4 The method of freeing adopted should be decided by a competent person. It should avoid the hazards outlined in **18.5.2** and may involve one or more of the following measures:

- a) provision of suitable restraint during freeing operations;
- b) loosening of adjacent framework connections;
- c) judicious use of jacks, crowbars and pulling devices;
- d) careful burning without causing harm to existing assembled portions of the framework and persons involved.

19 Slinging of loads

19.1 General

Precautions should be taken in the slinging and handling of loads in accordance with the recommendations given in CP 3010. For a specification for chain lever hoists refer to BS 4898.

19.2 Lifting and slinging

19.2.1 When lifting:

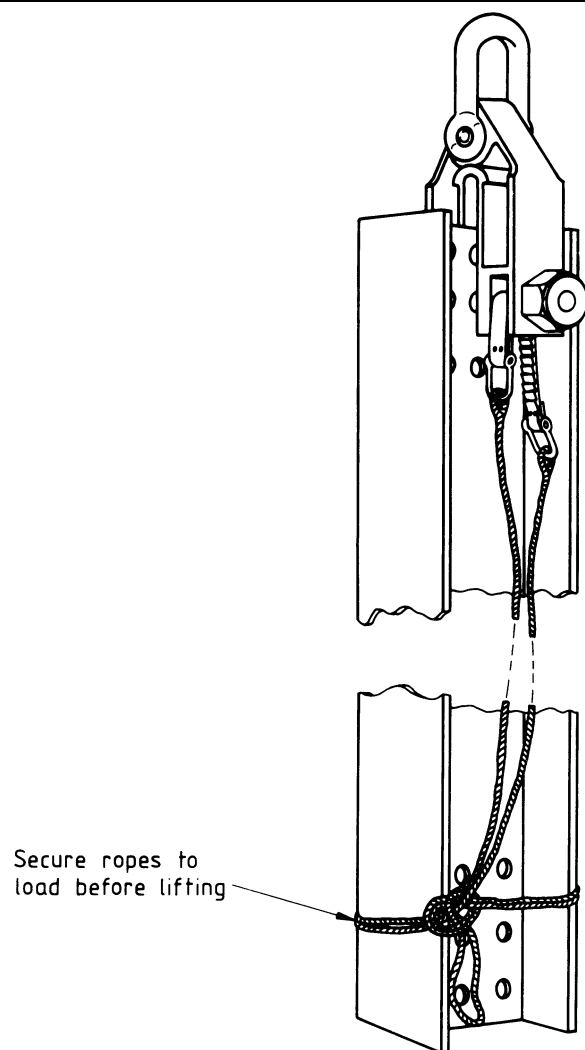
- a) the total weight to be lifted should be established and should include lifting gear such as slings, lifting beams, crane blocks and rope falls as appropriate;
- b) the use of special devices such as tilting shoes for columns and lifting frames for sub-assemblies should be considered;
- c) all lifting frames and beams should be designed, tested (when applicable) and should display prominently the safe working load and the self weight.

19.2.2 When slinging, it is particularly important that use is made of:

- a) a remote release system to obviate the need for access to release slings at height (see Figure 1 and Figure 2);
- b) lifting aids such as lifting beams to prevent overloading the slings and to provide support for slender flexible assemblies such as roof trusses;
- c) two-leg slings, wherever possible, as they provide greater stability of the load, although care should be taken to ensure that the included angle is within the safe range;
- d) packing to help avoid damaging the slings and prevent the load slipping.

19.2.3 Other factors to be considered include:

- a) preventing unwanted rotational movement of loads, particularly long loads, by using hand lines fixed near the ends of each load;
- b) avoiding shock loading on slings by lifting and lowering slowly at all times;
- c) using timber battens on which to land loads so that the sling can be removed easily and is not damaged by crushing.



NOTE 1 After lifting the material the shackle is released by pulling the release ropes first one way and then the other five or six times. The ratchet action withdraws the pin allowing the shackle to be lifted clear of the column.

NOTE 2 This figure is reproduced by courtesy of Dawson Construction Plant Limited.

Figure 1 — Use of typical remote release shackle